Networking and Information Technology

Computer Science

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President’s Council of Advisors on Science and Technology
Washington, DC
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Computing Technology (R)Evolution

1935  1946  2010
Social Impact
Three Stories:
Google
Model Checking
Machine Learning
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<tr>
<th><strong>Senior Personnel</strong></th>
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<tbody>
<tr>
<td>Name: Garcia-Molina, Hector</td>
<td>Worked for more than 160 Hours: Yes</td>
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<td>Contribution to Project:</td>
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<tr>
<td>Name: Paepke, Andreas</td>
<td>Worked for more than 160 Hours: Yes</td>
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<td>Contribution to Project:</td>
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<td>Project Director</td>
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<th><strong>Post-doc</strong></th>
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<tr>
<th><strong>Graduate Student</strong></th>
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<tr>
<td>Name: Page, Larry</td>
<td>Worked for more than 160 Hours: Yes</td>
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<td>Contribution to Project:</td>
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<tr>
<td>Name: Chang, Ed</td>
<td>Worked for more than 160 Hours: Yes</td>
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<td>Contribution to Project:</td>
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<tr>
<td>Name: Chang, Kevin</td>
<td>Worked for more than 160 Hours: Yes</td>
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Sergey Brin
Co-Founder & President, Technology

Sergey Brin, a native of Moscow, received a bachelor of science degree with honors in mathematics and computer science from the University of Maryland at College Park. He is currently on leave from the Ph.D. program in computer science at Stanford University, where he received his master's degree. Sergey is a recipient of a National Science Foundation Graduate Fellowship as well as an honorary MBA from Instituto de Empresa. It was at Stanford where he met Larry Page and worked on the project that became Google. Together they founded Google Inc. in 1998, and Sergey continues to share responsibility for day-to-day operations with Larry Page and Eric Schmidt.

- Sergey's research interests include search engines, information extraction from unstructured sources, and data mining of large text collections and scientific data. He has published more than a dozen academic papers, including Extracting Patterns and Relations from the World Wide Web; Dynamic Data Mining: A New Architecture for Data with High Dimensionality, which he published with Larry Page; Scalable Techniques for Mining Casual Structures; Dynamic Itemset Counting and Implication Rules for Market Basket Data; and Beyond Market Baskets: Generalizing Association Rules to Correlations.

- Sergey has been a featured speaker at several international academic, business and technology forums, including the World Economic Forum and the Technology, Entertainment and Design Conference. He has shared his views on the technology industry and the future of search on the Charlie Rose Show, CNBC, and CNNfn. In 2004, he and Larry Page were named "Persons of the Week" by ABC World News Tonight.
The Google search engine was developed as part of the project. It is now a company (www.google.com)
Layers of Abstraction
Search

Natural Language Processing, Text and Information Retrieval, User Interfaces

PageRank

Algorithms, Data Structures

MapReduce

Programming Languages, Software Engineering

GFS, BigTable, Chubby

Reliability, File Systems, Operating Systems, Consensus

Server Farm

Distributed Systems, Networking, Storage Systems

Electronics, Digital Circuits, Signal Processing
Story 2: Model Checking

M: Traffic Light Controller

P: No Collisions

Model Checker

Does M satisfy P?

Yes!

No, and here’s an example of why not.
Story 3: Machine Learning
Drivers of Computing

Science

• What is computable?
• P = NP?
• What is intelligence?
• What is information?
• (How) can we build complex systems simply?

Technology

Society
Data to Knowledge to Action
Cell + Cloud

credit: M. Lam
Cyber + Physical
(e.g., “Smart X”)
Humans + Computers
(“Socially Intelligent Computing”)
Societal Drivers
High Expectations
24/7, 100%, anyone, anything, anytime, anywhere

Diversity in Classes

Personalized
Societal Grand Challenges

Energy
Environment
Climate Change
Sustainability

Food, Water

Healthcare

Education

Transportation

Security, Safety
Science: Five Deep Questions in Computing

• What is computable?

• \( P = \text{NP} \) ?

• What is intelligence?

• What is information?

• (How) can we build complex systems simply?
High-Level Remarks:

Education
NITRD
Administration Priorities
Education: Computer Science is Part of STEM

• Every educated person in the 21st Century needs to know core computer science concepts (aka “computational thinking”):
  • Abstraction, algorithmic thinking, representing data, expressing computations, finding patterns, verifying and debugging,…

• “Computation is the third pillar of science, along with theory and experimentation.”

• Recommendation: Add Core Ideas in Computer Science to the National Academies “Conceptual Framework for New Science Education Standards” report.
NITRD and Federal Agencies

• Computer science goes way beyond high-speed computing, the current major focus of NITRD.
  – *Recommendation: NITRD should rebalance its foci and update its portfolio.*
• Coordination has worked reasonably well and NITRD is responsive to the fast-track requests.
• For *Energy*, Dept of Energy needs to broaden its view of the role of computer science, networking and information technology.
• For *Healthcare*, it’s about knowledge-based lifelong patient-centric wellness, not just electronic health records. NITRD should work with non-NITRD agencies, e.g., ONC, VA, CDC, ...
• For *Education*, it’s about advanced computing technologies to enhance learning, not just computers in the classroom. Ensure computer science is part of STEM. NITRD should work with Dept. of Education.
• For *Cybersecurity*, leadership needs to come from the top
  – Government + Industry + Academia, Classified + Unclassified
Computer Science and FY12 Administration Priorities

- Economic prosperity, competitiveness, innovation
- Healthcare
- Energy
- Climate change
- Sustainability
- National security

{ Advances in computer science will be instrumental to make progress in all these areas. }
High-Level Takeaway Points

- Advances in computer science are a key driver of economic competitiveness and innovation.
  - Innovation in computer science happens at an unparalleled rapid pace.
- Advances in computer science transform society.
- Advances in computer science are instrumental in addressing our major national and societal challenges, e.g., energy and the environment, education and life-long learning, healthcare, open government, and national security.
  - Tackling these challenges requires advances in computer science, not merely the application of existing technology.
- Advances in computer science accelerate the pace of discovery and innovation in nearly all other fields.
- Sustained federal investment in long-term fundamental computer science research has had high payoff and needs to be continued.
- Computer science has a rich intellectual agenda.
  - It is the discipline that underlies networking and information technology.
- Well-educated citizens of the 21st C should learn core computer science concepts.
Thank You!
Drivers of Computing

Science

- What is computable?
- $P = NP$?
- What is intelligence?
- What is information?
- (How) can we build complex systems simply?

Technology

Society